Hacking into e-waste

Hackerspace Solutions to E-Waste

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Assuming continuity in the current growth rate of e-waste, we can expect that global production will reach as much as 120 million tonnes/year by 2050. This article concerns hackerspace initiatives that provide inspirational solutions towards tackling our planet's ever-growing stockpiles of e-waste.

Introduction

E-waste is generated at a rate of 50 million tonnes each year around the world. The UK alone is responsible for producing half a million tonnes of e-waste per annum, and according to recent Basel Action Network reports, the UK remains the worst European country for illegal exportations of toxic e-waste to developing countries. Countries such as India, Nigeria and China have crude structures in place that enable the extraction of valuable metals and components. The working environment is extremely hazardous, and the workers are typically paid little for their efforts. Typically, between 10-20% of UK's e-waste is recycled, with the remaining 80% sent to landfills or incinerators, damaging both the environment through harmful leachates and dioxins, and human health.

The majority of materials in e-waste include metals such as iron and steels, copper, aluminium and plastics such as high impact polystyrenes, acrylonitrile-butadiene-styrene co-polymers, and polypropylenes. Precious metals such as silver, gold, palladium, iridium, and rare earth metals; exist in smaller fractions. Extraction of these metals is hazardous requiring e.g. hydrogen peroxide, hydrochloric and nitric acids, and sodium cyanides, which in turn necessitates highly specialised procedures for disposal. In several developing countries the separation and deconstruction of such e-waste is a risk undertaken for the most part by children, a practice that is both ethically problematic and concerning. Less hazardous possible alternatives to chemical extraction has been suggested as plausible via microbial processes. Both the bacterium *C. biolaceum* and the fungus *A. niger*, have been proposed as suitable alternatives for the extraction of gold from gold plated e-waste, while the bacteria *T. ferrooxidans* and *T. thiooxidans*, as well as fungi *A. niger* and *P. simplicissimum*, have been shown to extract other metals from e-waste, such as lead, copper and aluminium. Biological technologies such as these are of little benefit in the developing world where people willingly expose themselves to hazardous chemicals to make economic ends meet. Moreover, many of the microorganism-based approaches are still at a low Technology

Readiness Level (TRL) and as such, the likelihood of mass upscaling and utility is presumably, relatively low.

Upcycling e-waste in Africa

An alternative to e-waste extraction, upcycling, has recently experienced a growth in impetus. This alternative not only resolves many of the issues of human exposure to hazardous chemicals, but also adds economic value to e-waste. The upcycling of e-waste into higher-value products and machines is made possible through both global and local networks of support, often taking the form of hackerspace communities. Born initially through small activities in Germany in the early 1990s (e.g. the Berlin-based C-Base), hackerspace movements are now found around the world. The majority of them are in Europe and North America; however, many new hackerspaces have recently been launched in Asia, Africa and South America. Many of the rising hackerspaces in economically developing African countries are directly aimed at resurrecting e-waste to create entirely new products with at best, market potential, and at the very least utility potential within the local community. The Agbogbloshie Makerspace Platform (AMP) is an excellent example of positive impact through e-waste upcycling. Located in one of the most polluted cities in the world (Accra, Ghana), AMP has direct access to the Agbogbloshie scrapyard, hosting a range of aeronautical, automotive, electronics and household scrap. Rather than consenting to the idea that the scrapyard is a toxic e-waste dump, AMP employs the philosophy of upcycling and of safe urban open-air manufacturing. AMP views the scrapyard as an ecosystem for machine hacking where the materials and components are freely available from reclaimed e-waste sources. The AMP being essentially an safe hackerspace hub for machine hacking activities, already provide disassembly templates for different types of e-waste (e.g. microwaves, televisions, air-conditioners, refrigerators, mobile phones and PCs), ensuring that local workers engaged in "hacktivities" are able deconstruct and rework the e-waste safely. Another West African country, Togo, is home to WoeLab, the first African hackerspace set up in 2012. A relatively famous WoeLab success story is the "W.Afate", a 3D-printer made almost entirely from e-waste. This said, WoeLab are big thinkers, having recently suggested in the NASA Space APP Challenge (hackathon) that e-waste be upcycled and sent to Mars. Rather than sending e-waste to developing countries, WoeLab posits that it would be better to reconstruct e-waste into space-technology for explorative purpose, at a fraction of the cost of higher-end technologies.

The growing need for e-waste/hackerspace activities in Asia

Asians produce only *ca*. one fifth of the e-waste per person as compared to Europeans. Yet due to the significantly greater population size within the continent, Asia

generates over 40% of the world's e-waste (> 20 million tonnes). Heightening levels of e-waste in Asia correlates quite naturally, with changes in the ease of availability of electronic products, with an > 60% increase of e-waste produced across the entire continent within the last 5 years. Consultation of online hackerspace listings elucidates < 100 hackerspaces within the entire continent of Asia. This brings to light the relatively low levels of activity relative to the population size of the continent. Europe in comparison has a significantly lower population size than Asia, but boasts > 520 listed hackerspaces, several of which are already engaged in upcycling e-waste. Given the scale of e-waste in Asia, it is somewhat surprising that of the *ca.* 100 listed hackerspaces, only a handful of them have reported a focus on upcycling, reconstructing, or managing e-waste. This said; there is growing impetus for the improved management and upcycling of e-waste, the SEA Makerthon organised annually by SEAMNET being an aspirational example. In 2016, this event comprised hackerspace enthusiasts in ten cities across South East Asia working through summer to 'design a world with zero waste'. Some of the inventions included; IoT recycling kiosks for e-waste sorting and management, upcycled e-waste tracking devices, upcycled dehydration tech, and e-waste reconstructed to turn food into high quality fertiliser. A dissimilar, yet equally creative venture (4R Recycling Pvt Ltd), this time in Bangalore, India, formulated a pipeline to reconstruct e-waste into household showpieces. Though here the e-waste is not upcycled *per se*, its reconstruction into creatively designed showpieces requires a different level of artistry and innovation, not usually seen in typical upcycling processes.

Recognising the need for additional e-waste upcycling activities in Asia our most recent GCRF project at The University of Edinburgh considered the upcycling of e-waste in Nepal, to create robots and robotic parts. In 2011, the Nepalese Government enacted the Solid Waste Management Act with aims to maintain a clean and healthy environment by minimising the adverse effects of solid waste on public health and the environment. E-waste is currently a major source of concern in the Nepalese capital Kathmandu, where it is dumped into landfills at a rate of *ca*. 18K tonnes/annum. There are therefore, sizeable volumes of material available for recovery and upcycling into marketable products. In our project, we help develop reverse-engineering skills at an HEI, Khwopa Engineering College, in parallel to product development R&D objectives at Green Nepal Recycling, a newly created SME in Nepal with a 'trash to treasure' focus. Nepal has a knowledge gap, and indeed, skills shortage in the area of upcycled products from e-waste. Creating programs for engineering students so that they fill these gaps in knowledge and skill is our means to instigating a new hackerspace community in Asia, focussed on e-waste derived upcycled products. We anticipate in the longer term, that this will strengthen local economies in Kathmandu, whilst concurrently decreasing the large volumes of landfill e-waste that Nepal has

gathered over decades. Our project is particularly useful to the Khwopa Engineering College (affiliated to Purbanchal University) as it provides new material with which the college will reinforce their taught course on Solid Waste Management. Although Covid-19 has put on pause our activities in Nepal for the time being, when we return to Nepal, we will continue our hackerspace activities, the primary application focus of which is upcycling of e-waste to create 'robotic farm hands'.

Final remarks

How we manage our ever-increasing stockpiles of e-waste will depend to an extent, on how we view them. As it stands, e-waste dumped into a landfill has no market value, but through innovation and creative design thinking, the same waste can be upcycled and sold. To date, the extraction of precious metals is an economic driver that exposes both people and the environment in developing countries to hazardous toxic substances. Increasing the numbers of hackerspace communities, especially in developing countries, might be a viable solution to the problems of e-waste management, and to problems associated to human and environmental health. Hackerspaces have the additional benefits of encouraging community development, skills development, economic development, and creative thinking.

"The best way to predict the future, is to create it" – Peter Drucker

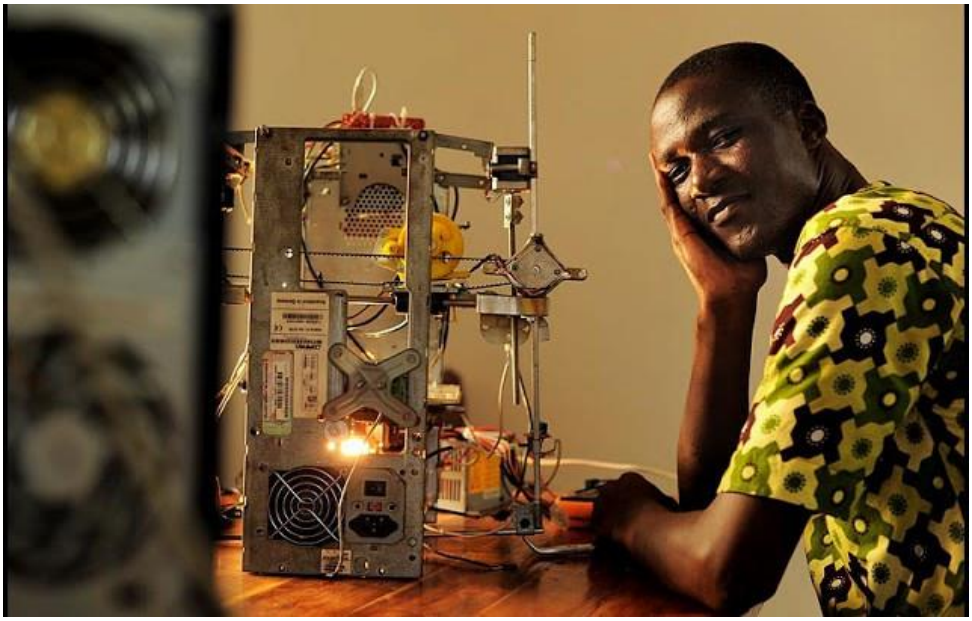
Figures:

1. Burning sheathed cables to recover copper at the Agbogbloshie e-waste landfill near the center of Accra, Ghana's capital city - This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license – **Credit: Muntaka Chasant**
   Source: https://commons.wikimedia.org/wiki/File:Agbogbloshie,_Ghana.jpg

2. Electronic waste at Agbogbloshie, Ghana - This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license – **Credit: Muntaka Chasant**
   Source: https://commons.wikimedia.org/wiki/File:Electronic_waste_at_Agbogbloshie,_Ghana.jpg

3. W.Afate 3D printer made from e-waste in Togo - This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license – **Credit: WoeLab**
   Source: https://atlasofthefuture.org/project/woelab-3d-printer/

4. Afate Gnikou and his e-waste 3D printer - This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license – **Credit: WoeLab**
   Source: https://hackaday.com/2013/10/13/3d-printer-made-from-e-waste-in-africa/



5. Dismantling electronic waste in New Delhi, India - This file is licensed under the Creative Commons Attribution-Share Alike 2.0 Germany license – **Credit: Matthias Feilhauer (Benutzer: thousandways)**
   Source: https://commons.wikimedia.org/wiki/File:Ewaste-delhi.jpg